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Research Program on the Nutritive Value of Canned Foods

Introduction

The nutrition research program on canned foods which is being sponsored by the National Canners Association in cooperation with the Can Manufacturers Institute has been in progress for two years and the details for continuing this research for the third year have been worked out. A considerable part of the program thus far has dealt directly with finding out which commercially canned foods as now manufactured may be expected to contain nutritionally significant quantities of six vitamin factors and three mineral constituents, namely, vitamin C (ascorbic acid), vitamin A or carotene (provitamin A), four "B" vitamins (thiamine, riboflavin, niacin or nicotinic acid, and pantothenic acid), and the mineral constituents—calcium, iron, and phosphorus.

As results were obtained they were released confidentially to certain Government agencies for use in the formulation or evaluation of wartime military and civilian dietaries. They also have served as the basis of studies for the purpose of increasing the nutritive value of canned foods.

Previous vitamin research on canned foods has demonstrated that in modern canning practice various factors, such as the exclusion of air in preparatory operations and the processing by heat in sealed containers, are favorable for the retention of certain food values, particularly vitamin C. It is recognized, however, that the initial vitamin content of canned food solids is reduced by dilution with brine or sirup, or by removal of vitamin-bearing tissues of the raw material during preparation. In certain home preparatory methods, also, it is known that severe losses of certain vitamins may occur.

Little is known at the present time regarding the influence that temperature or time of storage to which canned foods may be subjected may have on their retention of vitamins. Although much has already been published concerning vitamin and mineral retention during various cooking and canning procedures, the studies on canned foods

have been based mainly on small-scale experiments and do not necessarily represent commercial operations. Accordingly, the present work is so planned as to: (1) ascertain what important nutrients are present in canned foods as now manufactured; (2) secure the maximum retention of nutrients during canning; (3) obtain specific information on the effects of temperature and time of storage on vitamin retention; and, (4) determine the effects of food preparatory operations which are followed in the home or in mass feeding as in the case of large groups of military personnel.

This report on the research program on the nutritive value of canned foods has been prepared in order that the industry may be informed of the progress which has been made. The report does not include any of the analytical data which have been developed, because of the collaborating universities' requirements that data should not be distributed prior to its publication as a contribution from the research laboratories of the institution at which the work was performed. A number of reports by the collaborating research laboratories are scheduled for early publication.

The nutrition research program is being administered through an executive committee of six members, three of whom represent the National Canners Association, and three, the Can Manufacturers Institute. The executive committee is charged with the organization and execution of the program. It is assisted by three regional subcommittees—Eastern, Midwestern and Western—which supervise the details of the program in their respective regions. A special industry committee of seven members, representing the canners and the can manufacturers, acts in an advisory capacity to the executive committee. Early in the program an industry advisory committee

of approximately forty members was appointed to consider special questions.

Assays of Nutrients in Commercially Canned Foods

To secure information concerning the nutritive value of canned foods as they are now manufactured, 823 samples, representing 32 different canned food items, were collected throughout the country during 1942 and the spring of 1943. These were examined for vitamin content in research laboratories of the University of Arizona, the University of Texas, and the University of Wisconsin. Of all those collected during the 1942-43 season, 561 samples, or 67 per cent, were analyzed for moisture, ash, crude fat, crude fiber, protein, and carbohydrates. In order to gain information concerning important mineral constituents, calcium, iron, and phosphorus also were determined on the latter samples. Most of the proximate and mineral analyses were made at the University of Maryland.

The 823 samples of canned foods selected for the first year's assays included the major non-formulated products, and samples of these products were obtained from all of the canning districts which produce the items in relatively large quantities. Samples of many of the products were obtained at two or three times during the canning season, in order to observe any variation in nutrients which might occur. The grade of product selected for analysis was that which predominated in production at the time the sample was procured. The samples, in most instances, were taken from canneries by representatives of the industry, and "run of the mill" samples were obtained to provide as good an indication as possible of the nutritive value of the major products canned in the United States.

Similar studies were made during the second year but on a somewhat reduced scale, and a few additional products were included. The vitamin assays were conducted during the second year at the University of Chicago and the University of Wisconsin. The same vitamin factors were studied as in the first year, except that pantothenic acid

assays were not made. Altogether, 550 samples were collected for this purpose, and proximate and mineral analyses will be made on most of these samples. The following is a list of products studied during the two-year period:

Apricots, halves, unpeeled	Mushrooms
Asparagus, all-green	Orange juice
Asparagus, white	Peaches, clingstone
Beans, baked	Peaches, freestone
Beans, green, cut	Pears
Beans, lima, green	Peas, Alaska
Beets, sliced	Peas, sweet, wrinkled varieties
Blackberries	Peppers, red
Blueberries	Pimientos
Carrots, sliced	Pineapple juice
Cherries, red sour pitted	Pineapple slices
Corn, white, cream style	Potatoes, sweet
Corn, yellow, cream style	Prunes, Italian
Corn, white, whole kernel	Salmon
Corn, yellow, whole kernel	Sardines in oil
Grapefruit juice	Sardines in tomato sauce
Grapefruit segments	Shrimp
Kraut	Spinach
Mackerel	Tomatoes
	Tomato juice
	Tuna
	Turnip greens

The results obtained from these vitamin assays will add greatly to the existing knowledge of the vitamin content of canned foods, especially with respect to the presence of certain of the "B" vitamins. They show that, although no single product contains all of the nutrients in appreciable quantities, yet, in general, many commercially canned foods do contribute significant amounts of important nutrients to the diet. The data on vitamin content obtained through the first year's work will be published in the August, 1944, issue of the *Journal of Nutrition*. Reprints will be available through the Association offices.

Studies on Retention of Nutrients during Canning

It is not enough merely to know the vitamin and mineral content of canned products as now manufactured if, by further research, procedures can be found to raise the level of these nutrients in the products. So, special studies, designed to ascertain the degree of over-all retention of vitamins during canning and to seek improvement in existing canning methods by studying the degree of vitamin retention during specific canning operations, were conducted during the second year in the East at Pennsylvania State College, in the Midwest at the University of Wisconsin, and in the West by the Western Branch Laboratory of the National Canners Association.

Preliminary to the cannery studies proper steps were taken to insure representative sampling at all stages

from raw material to finished product and to determine the appropriate assay methods for the several nutrients. It was desired to estimate first the over-all retention of nutrients—that is, the effect of the entire canning procedure, as determined by comparing analyses of the raw material and the finished product representative thereof—and then, in those products showing an important difference, to determine what steps in the canning procedure were principally responsible for the change and to recommend changes in canning procedures where they may be beneficially employed for greater vitamin retention.

CANNING STUDIES IN EAST

The studies in the Eastern region were conducted at Pennsylvania State College under the direction of Dr. N. B. Guerrant. These covered changes in vitamin content of vegetables and fruits as they passed through the various stages of commercial canning operations. The studies involved ten foods and included the products of 24 commercial canneries, all of which were located in New York State. Some of the foods were sampled at as many as six different stages of the canning procedure, and most of these samples were assayed for moisture, vitamin C, carotene, thiamine, riboflavin, and niacin. More than 225 samples, requiring some 1,100 assays, were involved. The data obtained in these and similar studies should lead to improvement in canning techniques, and thus to canned foods of greater nutritive value. A report of these studies will be prepared for publication.

CANNING STUDIES IN MIDWEST

The work in the Midwestern region was done at the University of Wisconsin under the direction of Professor C. A. Elvehjem, with the cooperation of the Midwest Regional Committee. The products studied were all-green asparagus, green beans, lima beans, yellow whole kernel corn, and peas; the factors studied were vitamin C, thiamine, and riboflavin. In the case of green beans, lima beans, and yellow whole kernel corn, studies were also made on niacin. Work on asparagus was done in two canneries, on green beans in three canneries, on lima beans in three canneries, on corn in three canneries, and on peas in seven canneries. Samples were taken at various points along canning lines in order to determine the changes in vitamin content due to specific canning operations. A report of this work will be published as a scientific contribution in the same manner as is intended for

that done at Pennsylvania State College. A vitamin C survey in 12 grapefruit juice canneries in the Rio Grande Valley was also conducted during the 1944 spring pack. Samples were taken of the freshly extracted juice, and after finishing, after holding, at the filler bowl after pasteurizing, and from the cooled cans whenever possible. A report of this work is being prepared for publication.

CANNING STUDIES IN WEST

In the West the following eleven products were studied: apricots, all-green asparagus, white asparagus, green beans, grapefruit juice, orange juice, cling peaches, spinach, tomatoes, tomato juice, and tomato paste. The work was done in 40 canneries and the main factor studied was vitamin C, because the products involved were generally recognized as those in which that vitamin would be present in important amounts. A few products were assayed also for carotene, thiamine, riboflavin, and niacin, and on all samples the moisture content was determined.

An outstanding observation resulting from these cannery investigations is the great variation in vitamin content of the raw material. Part of this can be attributed to variation in maturity and growing conditions, but in any cannery wide variations have been found, and much of this appears to be beyond the control of the cannery management. This phase requires serious consideration and further investigation. However, information will become available from these studies and from other sources, which, if applied, should bring about considerable improvement in the retention of nutrients in a number of our more important canned products.

Factors Influencing Retention of Certain Vitamins

It would appear that vitamin C is the vitamin most easily lost during preparation for canning. It is water soluble and therefore may be partially extracted during boiling and blanching. Vitamin C is also susceptible to oxidation. It has further been established that many food products contain enzymes which accelerate the rate of destructive oxidation of vitamin C. Air incorporated during manufacture hastens the oxidation of vitamin C in most products, and oxidation proceeds more rapidly as the temperature is raised. On the other hand, fortunately, vitamin C is not readily destroyed in the absence of air. To decrease loss of vitamin C, therefore, it is important to in-

activate the enzymes rapidly by heating for a short time at a high temperature, and wherever practicable to apply effective denaturation procedures for the removal of air from the product.

Thiamine also may be extracted, although not quite as readily as vitamin C. Thiamine is not readily destroyed by oxidation as is vitamin C, but is destroyed by heating. It is important, therefore, that the heating of foods rich in thiamine be confined as far as possible to the sterilizing processes which must be used in order to prevent food poisoning and losses from spoilage. Riboflavin also may be extracted but, unlike thiamine, is not readily destroyed by heat and is not subject to oxidation. Another "B" vitamin, niacin, also is water soluble, but is unusually stable to heat and oxidation. Carotene is the only vitamin included in these studies which is not soluble in water. It is considered to be stable at sterilizing temperatures in the absence of oxygen.

In the tests which have been made, the principal loss of vitamin C and the other water-soluble vitamins, with the possible exception of thiamine, has occurred during blanching. The amount depends primarily on the relative amount of surface area of the product exposed to the blanch water and on the time and temperature of the blanch. Permeability of the vegetable tissue and the activity of enzymes may also play important parts. Spinach, in particular, is subject to serious loss during blanching because of its extremely large surface area and because it contains enzymes which promote destruction of vitamin C. Vegetables having lesser surface areas, such as peas and asparagus, show better retention of vitamin C. The design and mode of operation of a particular blancher often is of greater importance than the time and temperature of blanch. Some types of blanchers may cause greater losses due to extraction because of more rapid circulation of the blanch water or more intimate contact between the blanch water and the product.

Canning Studies Planned for 1944 Season

The University of Wisconsin will continue studies on the effect of canning operations on the vitamin content of vegetables with particular reference to blanching studies. Various types of blanching equipment will be studied as well as the effects of variations in time and temperature, circulation, and concentration of dissolved solids during blanching procedures. Studies will be

concentrated on peas, green beans, lima beans, and spinach. Steam blanching studies will be conducted where possible. The vitamin factors, ascorbic acid, thiamine, and niacin, will be determined in the products to trace the solubility losses during blanching.

This type of research will be continued on an extensive scale in the West throughout the year. It is planned to study conditions in western canneries packing apricots, green beans, whole kernel corn, orange juice, clingstone peaches, freestone peaches, peas, Italian prunes, spinach, tomatoes, tomato juice, tomato paste, and possibly sardines. The vitamin factors to be studied will be carotene, vitamin C, thiamine, riboflavin, and niacin. In all regions some additional canning studies will be conducted in connection with the procurement of samples for the storage studies.

Storage Studies

During the first year exploratory storage studies were made at Pennsylvania State College by Dr. N. B. Guernant to obtain information on the retention of vitamin C, carotene, thiamine, riboflavin, and pantothenic acid in green lima beans, whole kernel corn, and tomato juice. The storage temperatures were 30°, 42°, 55° and 110° F. and observations were made over a period of twelve months. The data indicate that the vitamin content of each product was affected adversely when stored at the higher temperatures for an extensive period of time. The proportion of the original vitamins retained by the three products varied somewhat with the product under investigation and also with the different vitamins.

EFFECTS OF TEMPERATURE AND TIME OF STORAGE ON VITAMIN RETENTION

To obtain more information on the effect of storage temperature, a large scale project is now under way. The storage temperatures for the tests are 50°, 65° and 80° F. Well-controlled packs will be prepared and tests will include the following five vitamin factors: vitamin C, carotene, thiamine, riboflavin, and niacin. The products will be tested after storage for periods of four, eight, and twelve months, and the tests will be continued up to a period of two years. When the samples are being prepared for the storage studies, it is planned as far as possible to obtain information on the vitamin content of the raw material used, and on changes in vitamin content of that material at various steps during preparation and processing, thus obtaining a

complete history of the vitamin content of the product from the time of harvest through to the end of the storage period. It would appear that such controlled studies on representative samples of canned foods of known history would serve to establish vitamin retention curves.

COMMERCIAL WAREHOUSE STORAGE

To permit comparison of the effects on vitamin retention in canned foods, of actual warehouse storage with storage under controlled conditions, it was decided to procure additional samples of three products—orange juice, peas and tomatoes—at the same time such samples are drawn for the regular storage studies, and to hold these samples in commercial warehouses at nine locations throughout the country. At the end of one year's storage, samples from each locality will be returned to the universities and assayed for thiamine and vitamin C content. Vitamin content at the start of the storage period will already have been obtained on comparable packs; hence, the relative degree of retention of these two vitamins after one year's storage under commercial conditions will be revealed. Supplementary information, such as complete Weather Bureau records for the above localities during the storage period, type of warehouse, etc., will also be obtained. Such an experiment should prove to be a practical means of estimating actual storage effects under commercial warehousing conditions. The vitamin assays on the storage packs will be made at Pennsylvania State College and the University of Chicago.

Distribution of Vitamin Factors between Solid and Liquid Portions

To supplement the data on vitamin content of commercially canned foods, a study was made in the Department of Home Economics of the University of Chicago on the distribution of the water-soluble vitamins between the solid and liquid portions of canned vegetables and fruits. The vitamins included were vitamin C, thiamine, and riboflavin. The vegetables included in the study were all-green asparagus; green cut beans; green lima beans; carrots; whole kernel white corn; whole kernel yellow corn; peas; and spinach, each in No. 2 and No. 10 can sizes. The fruits studied were apricots, clingstone peaches, freestone peaches, pears, sliced pineapple, and Italian prunes, all in No. 2½ cans, and grapefruit segments in No. 2 cans. The investigators have completed the work and have prepared a report for publication in the August, 1944, issue of the *Journal of Nutrition*.

Vitamin Retention during Preparation for Serving

During the first year studies were carried out in the Department of Home Economics of the University of Chicago on the retention of vitamin C, thiamine, and riboflavin in canned vegetables during preparation for serving. One part of the work was planned to determine the effect on water-soluble vitamin content of large-scale preparation of canned vegetables, such as is done in Army mess kitchens. The method of preparation used was one considered to be typical in Army mess kitchens, where vegetables may be held hot from one-half to one and one-half hours after the preparation, and are usually dipped out with a slotted spoon, thus draining off most of the liquid. The products used were asparagus, baked beans, green beans, lima beans, carrots, yellow corn, spinach, and tomatoes.

The effect of family-size preparation of canned vegetables on the same water-soluble vitamins also was studied, with a view to comparing the following two preparation procedures: (a) the liquid was concentrated from one-half to one-fourth of its original volume; the solid portion was added and the material was then heated; and (b) the liquid and solid portions were heated together, but only the solid portion was assumed to be served. The investigators state that the retention of vitamin C was much more variable than that of the other two vitamins. They further state that in spite of the fact that there was greater chance of destruction of vitamin C during the somewhat longer heating period needed to concentrate the liquid in method (a), nevertheless for those products which were prepared both ways, the final retentions in this method were generally considerably better than in method (b) where the liquid was discarded. The canned products studied were green beans, lima beans, carrots, corn, peas, spinach, and tomatoes. A report of these investigations will be published in the *Journal of the American Dietetic Association* in the near future.

Distribution of Proximate and Mineral Nutrients between Solid and Liquid Portions

In connection with the proximate and mineral analyses, studies were made at the University of Maryland on the distribution of the mineral constituents, calcium, iron, and phosphorus—and also of total ash, protein, crude fat, crude fiber and carbohydrates—between the solid and liquid portions of the following canned vegetables: asparagus, green beans, green lima beans, beets, carrots,

corn, peas and spinach. This work has been completed and a report has been prepared for publication in a scientific journal.

Correlation between Bioassays and the Newer Chemical and Microbiological Methods of Analysis

Early in the planning of this nutrition research, considerable time and thought were given to selection of the methods to be used, particularly in the vitamin assays, and it was decided to have comparative studies made between the vitamin values obtained by animal feeding tests (bioassays) and values obtained by the newer chemical and microbiological procedures, to ascertain how close the correlation between results obtained by different methods of assay on selected types of canned foods may be expected to be. This work was done by Dr. N. B. Guerrant at Pennsylvania State College, using canned carrots, corn, peas, tomatoes, ham, and salmon, especially packed to ensure uniformity of can contents. The products were assayed for vitamin C, carotene or vitamin A, thiamine, riboflavin, niacin, and pantothenic acid by the bioassay method and by whatever newer methods were applicable. This proved to be a very valuable investigation because the data clearly indicated a definite need for extensive collaborative studies on the more promising vitamin assay methods, especially as applied to a wide variety of fruits and vegetables. At the last meeting of the nutrition executive committee it was decided to prepare special material to be used for check purposes by the various laboratories cooperating in this research program. Dr. Guerrant plans to publish the data in a suitable journal at an early date, and this should stimulate a more active exchange of test material between research laboratories interested in conducting vitamin assays.

General Program for the Third Year

The foregoing summarizes the various projects which have been conducted during the first two years. The major projects on storage studies now in progress and studies on the retention of nutrients during canning have been outlined. In view of the great interest in the relative food values of "fresh" vs. preserved foods as they reach the table for serving, it has been decided to make, on a small scale, tests which would include vitamin assays of certain food materials: (a) raw, at the time of harvest; (b) material prepared for serving after various intervals of storage under conditions simulating

those to which market produce is subjected; and (c) the same raw material canned commercially and then prepared for serving. Arrangements have been made to conduct this study at the University of Wisconsin.

Another project to be handled by the University of Wisconsin group has to do with a study of new vitamin B factors in canned foods. The factors to be studied are vitamin B₆ (pyridoxine), folic acid, and biotin. Analyses will be made of the following canned foods: All-green asparagus, green beans, carrots, yellow whole kernel corn, grapefruit juice, peaches, peas, salmon, spinach, and tomatoes. The canned products are to be obtained from canneries in accordance with the procedure followed for securing the assay samples during the first two years. It is planned to determine the vitamin content with respect to the new vitamin factors both on the raw material prior to canning and on the final canned product obtained from the same lot of raw material in order to obtain information on the over-all vitamin retention.

There are also a number of continuing projects on which work will be conducted as opportunity permits.

Publication of Results

It is a function of the Executive Committee to see that after the scientific findings have been developed they are published in suitable technical journals. Thus far, eight manuscripts have been prepared.

The committee plans to have ready shortly after these publications are released a semi-technical bulletin incorporating the essential details of the present research findings. The plan is to have the new bulletin similar in nature to NCA Bulletin 19-L, entitled "Vitamins in Canned Foods," the last edition of which was issued in 1937. The new bulletin will be a joint publication, with the NCA Research Laboratories in Washington and San Francisco collaborating with the research departments of the can companies.

Acknowledgment

Valuable assistance has been rendered by the university collaborators and research workers; the special advisory committees representing the canning industry and the can manufacturers; the many canners who cooperated in procurement of samples and in making their plants available for carrying out tests, and the can manufacturers who facilitated the collection, coding, and distribution of samples. This assistance is gratefully acknowledged.